EFFECTS OF MAGNETIC FIELDS ON FLAMES AND GAS FLOW

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Abstract -- Effects of magnetic fields on combustion and gas-flow were studied. Methane, propane and hydrogen gases were burned, and flames of these gases were exposed to gradient magnetic fields up to 1.6 T and 220 T/m. Flames bent so as to escape from magnetic fields of higher intensities. Apart from the combustion experiments, flows of gases such as carbon dioxide and oxygen were exposed to magnetic fields up to 2.2 T and 300 T/m. The flows of these gases with a flow velocity 20-140 ml/min were blocked or modified by the magnetic fields. The changes of flame-shape and gas-flow by magnetic fields are understood to be the result of the role of oxygen. Under the intensities of magnetic fields concerned, oxygen gases as paramagnetic molecules are not concentrated but are aligned so as to make a "wall of oxygen". The wall of oxygen presses back flames and other gases.

INTRODUCTION

Combustion is an oxidation reaction which involves both burning phenomena in the air and cell respiration in the living body. The effects of magnetic fields on combustion of alcohol and hydrocarbons with the aid of platinum catalysis have been studied to simulate in part the oxidation of organic matter in the living body, and it has been found that the combustion velocities and temperature are influenced by magnetic fields [1], [2]. The combustion temperature of alcohol decreased within a range 100-200°C when the combustion site was exposed to gradient magnetic fields in a range 20-200 T/m under 0.5-1.4 T [2]. It has been also observed that candle flames bend so as to escape from magnetic fields of higher intensities when flames are exposed to gradient magnetic fields of the same intensities as used in the case with platinum-catalyzed combustion [2].

Two hypotheses have been introduced in understanding the phenomenon; (1) Behaviors of charged particles in flames as plasma state are influenced by gradient magnetic fields, and (2) Oxygen gases as paramagnetic molecules are concentrated by gradient magnetic fields, and the concentrated oxygen gases exert pressure which tends to press back flames and other gases.

The purpose of the present paper is to clarify the mechanism for the phenomena observed in the combustion and flame experiments. Two different types of experiments are carried out. First, flames of burning gases such as methane and hydrogen gases are exposed to magnetic fields. Second, apart from combustion experiments, flows of gases such as carbon dioxide and oxygen are exposed to magnetic fields.

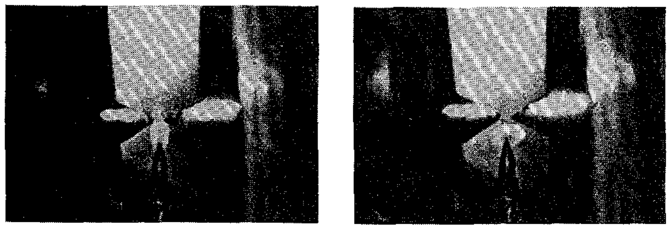
FLAMES UNDER MAGNETIC FIELDS

Methane, propane and hydrogen gases were burned in an airgap between wedge-shaped poles of electromagnet, and flames were exposed to gradient magnetic fields up to 1.6 T and 220 T/m.

Independent of the fuels, the shapes of flames were dramatically changed by gradient magnetic fields in the same manner as observed in the case of candle experiments.

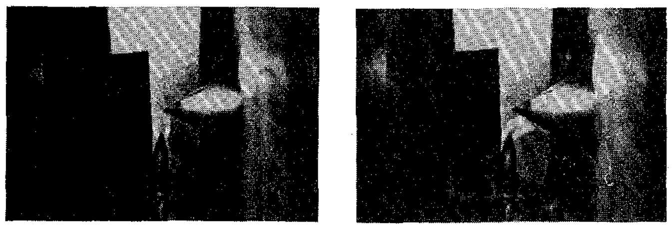
The results in the case of combustion of hydrogen gases are shown in Fig.1, and Fig.2.

In the experiment in Fig.1, flames were pressed down, and the shape of flames changed like a mushroom. The field intensity at the center of the airgap was 1.5 T, and the gradient was 200 T/m.



(a) (b)

Fig.1 Flames of hydrogen gas in gradient magnetic fields. (a) Flames before magnetic field exposures. (b) Flames during magnetic field exposures. The flames are pressed down. The field intensity is 1.6 T at the center of the airgap.



(a) (b)

Fig.2 Flames of hydrogen gas in gradient magnetic fields. (a) Flames before magnetic field exposures. (b) Flames during magnetic field exposures. The flames bend so as to escape from magnetic fields of higher intensities. The field intensity is 1.6 T at the center of the airgap.

In the experiment in Fig.2, a magnetic pole in the left side was turned by 90°,and the flames were exposed to the gradient magnetic fields. The flames bent so as to escape from magnetic fields of higher intensities.

GAS FLOW UNDER MAGNETIC FIELDS

Apart from the combustion experiments, flows of carbon dioxide, oxygen, nitrogen, argon and methane gases were exposed to magnetic fields up to 2.2 T and 300 T/m.

Figure 3 shows the experimental setup. Gases were supplied into the airgap between poles of electromagnet at a flow velocity in a range 20-140 ml/min through a gas-tube with 4 mm in diameter. The gases in the area beneath the outlet of gas-tube were continuously sampled into gas sensors through an inhalation nozzle. Oxygen and carbon dioxide were simultaneously measured.

The flows of these gases were blocked or modified by the magnetic fields.

When carbon dioxide was supplied with a velocity 45 ml/min, the flow pattern was clearly changed by magnetic fields as shown in Fig.4. In this experiment, the airgap was kept 2.5 mm wide, and the outlet of gas tube and the inhalation nozzle were positioned at z=8.0 mm and z=-8.0 mm, respectively.

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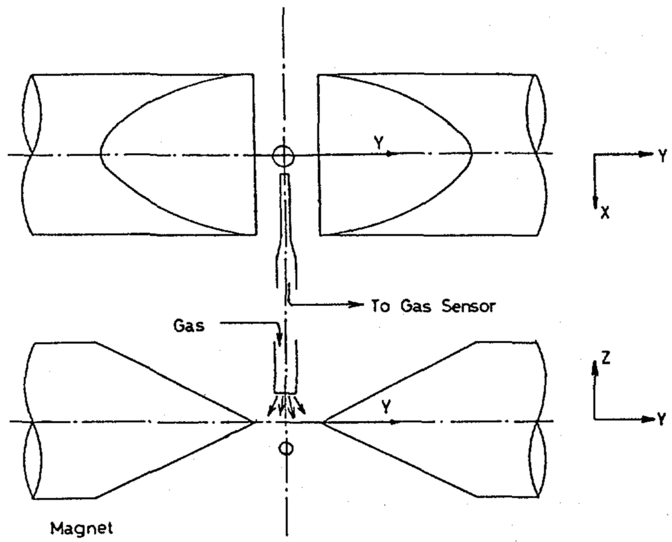

Fig.3 Experimental setup to observe gas flow under magnetic fields.

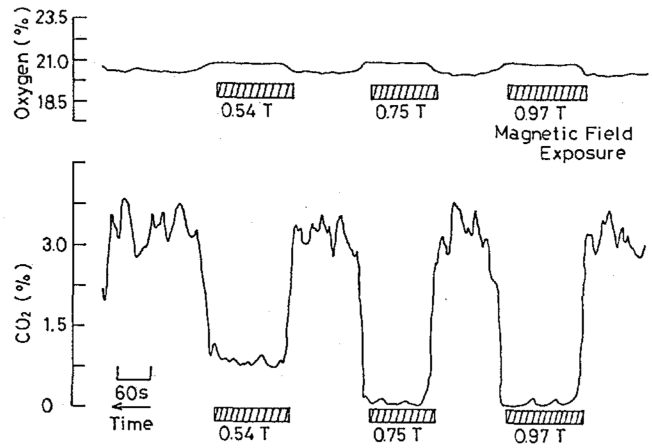

Fig.4 Gas-flow changes during magnetic field exposures when carbon dioxide is supplied. The flow of carbon dioxide is blocked by magnetic fields.

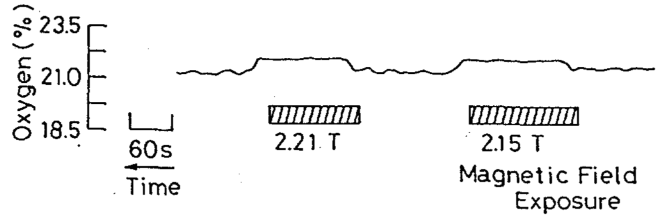

Fig.5 Gas-flow changes during magnetic field exposures when oxygen gas is supplied.

Before magnetic field exposures, oxygen concentration was slightly low (20.0 %) due to the gas flow of carbon dioxide. The concentration of carbon dioxide was around 3.0 % at the nozzle point. During magnetic field exposures, oxygen concentration was recovered to normal (21.0 %), and the flow of carbon dioxide was blocked.

When argon gas or nitrogen gas or methane gas was supplied, change in oxygen concentration with magnetic fields was also observed in the same manner as in the case of carbon dioxide.

When oxygen gas was supplied, the diffused oxygen gases were slightly trapped (1.0 %) by the magnetic fields as shown in Fig.5.

When no gases were supplied, oxygen concentration was kept a value 21.0 % and oxygen concentration was never increased by magnetic fields up to 2.2 T and 300 T/m. In other words, oxygen gases were not concentrated by the magnetic fields.

DISCUSSION

The phenomena observed in the present experiments were unexpected. Magnetic force acting on paramagnetic materials is proportional to the product of magnetic field and the gradient. If oxygen as a paramagnetic molecule could be attracted to the vicinity of magnetic poles, oxygen concentration should be higher in the area around magnetic poles than in the distant place. However, oxygen in the vicinity of magnetic poles was not concentrated by magnetic fields. Nevertheless, oxygen concentration, which was decreased by disturbance of external gases, was recovered to normal by the application of magnetic fields. In the same time, flow patterns of external gases were influenced antagonistically by the magnetic fields.

It seems that oxygen gases are not concentrated but are aligned or trapped so as to make a "wall of oxygen" during magnetic field exposures. The wall of oxygen presses back flames and other gases.

How can the wall of oxygen be formed? How strong is the wall of oxygen?

To widen the basic understanding of the wall of oxygen, changes in spatial distributions of carbon dioxide by magnetic fields were measured in the same experimental setup as used in Fig.3. Carbon dioxide was supplied at a flow velocity 45 ml/min through the outlet of gas-tube positioned at z=8.0 mm, and concentrations of carbon dioxide at different points in the airgap before and during magnetic field exposures were measured, shifting the position of the inhalation nozzle. The airgap was kept 7.0 mm wide, and the field intensity was 1.5 T at the center of the airgap.

The results are shown in Fig.6 and Fig.7. In each twin column at each lattice point, a column in the left side shows the concentration of carbon dioxide before magnetic field exposures and a column in the right side shows the concentration of carbon dioxide during magnetic field exposures.

As shown in Fig.6, the flow of carbon dioxide is clearly blocked by the wall of oxygen in the lower part of the airgap during magnetic field exposures.

The results in Fig.7 reveal us that the blocked gas-flow is reflected upwardly in the upper part of the airgap.

An experiment was carried out to obtain the strength of the wall of oxygen. Carbon dioxide was supplied into the airgap 7.0 mm wide from the outlet of gas-tube positioned at z=5.0 mm, changing the flow velocity. Concentration of carbon dioxide at the position z=-5.0 mm was measured continuously before and during magnetic field exposures. The field intensity was 1.36 T at the center of the airgap.

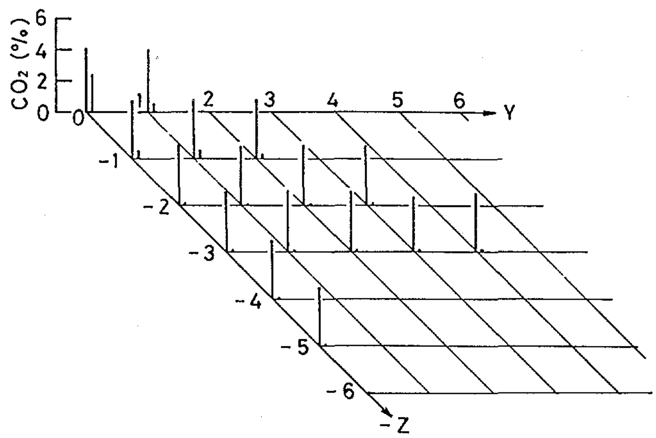

Fig.6 Spatial distributions of carbon dioxide in the lower half plane of the airgap when carbon dioxide is supplied at z=8.0 mm. A column in the left side at each lattice point shows carbon-dioxide concentration before magnetic field exposures and a column in the right side shows carbon-dioxide concentration during magnetic field exposures. Gas flow is blocked by the magnetic fields. The field intensity is 1.5 T at the center y=z=0.

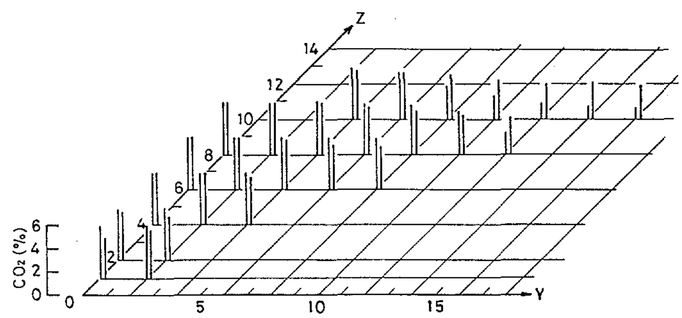

Fig.7 Spatial distributions of carbon dioxide in the upper half plane of the airgap when carbon dioxide is supplied at z=8.0 mm. Gas flow is reflected upwardly by the magnetic fields.

Figure 8 shows the results. Gas flow of carbon dioxide is blocked by the magnetic fields in a range of flow velocity up to 60 ml/min. Although the effect of magnetic fields on gas flow becomes weak in accordance with the increase in flow velocity, the gas flow is disturbed by magnetic fields. At a flow velocity in the range 70-140 ml/min, a part of gas flow is blocked and a part passes through the "wall", which results in a decreased outflow of carbon dioxide at the sampling point z=-5.0 mm.

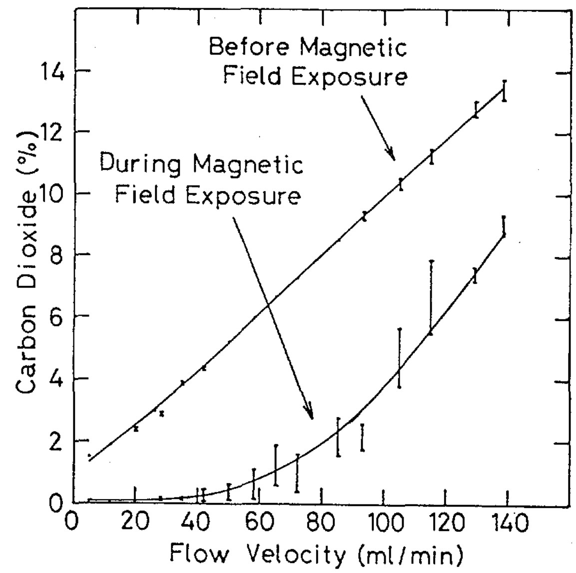

Fig.8 Concentration of carbon dioxide v.s. flow velocity. Flow of carbon dioxide is blocked or modified during magnetic field exposures. The airgap is 5 mm wide, and the field intensity is 1.36 T at the center of the airgap.

It is understood from the results obtained here that a "wall of oxygen" or an "air curtain" is formed along the line of magnetic fields in an area where both magnetic fields and the gradient are high enough. The wall of oxygen or the air curtain stretched between magnetic poles is not so stiff but strong enough to press back flames and gas flow.

It has been clarified that combustion can be controlled by magnetic fields. It has been also understood that flows of gases with different susceptibilities can be controlled by gradient magnetic fields using a gas with a high susceptibility such as oxygen.

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